TECHNICAL NOTE 357

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

An Economic Analysis Series
For Screening
Proposed Timber Management Projects

REPORT No. 3

Precommercial Thinning followed by Two Commercial Thinnings

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ACRONYMS USED IN THIS TECHNICAL NOTE

ACC	EXPLANATION
AC	Allowable cut
ACE	Allowable cut effect
B/C	Benefit/Cost
bd ft	Board feet Board foot
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
CT	Commercial thinnings Commercially thinned
FLPMA	Federal Land Policy and Management Act
GLO	General Land Office
IRR	Internal rate of return
IVST	Investment Analysis Data Processing Program
MBF	One thousand board feet (Roman Numeral M)
MMBF	Thousand, thousand board feet - million board feet -
NN.NN	Numeric input with decimal point indicated
O & C	Oregon and California Revested Railroad Grant Lands and Reconveyed Coos Bay Wagon Road Grant Lands
PCT	Precommercial thinning; precommercially thinned
PNW	Present net worth
SIMIX	Simulating intensive management of mixed harvest systems
SYU	Sustained yield unit
TN	Technical Note
TSS	Time sharing system (Honeywell 66/80 computer system)
USDI	U.S. Department of the Interior

FOREWORD

A Bureau of Land Management Sustained Yield Forest Unit is managed as a unique, ongoing, publicly-owned business enterprise. In addition to being cognizant of conservation, multiple-use and environmental concerns, the forest manager must also be production-oriented and financially responsible for the investment of public funds for intensive timber management purposes.

Sometimes the analysis of investment opportunities indicates that the forest manager can take immediate advantage of increased future yields from an investment in timber stand silvicultural treatments through the concept of the "allowable cut effect" (ACE). The annual increased cutting level, due to the ACE, consists of mature timber from anywhere within the sustained yield unit (SYU), except during the year that the treated stand is commercially thinned.

Under an even-flow timber harvest policy, when relatively low value thinnings are periodically offered for sale, some income from high value old-growth timber may be postponed during the time the thinnings make up a portion of the even-flow harvest level. In addition, the administrative costs involved in a thinning sale may prove to be considerably higher than those of regular sales of mature timber. The forest manager must be able to determine the economic feasibility of proposed investments which may affect present and future incomes and costs.

The concept of ACE and its application is dependent upon the availability of sufficient mature timber within the SYU. This requires the manager to be familiar with the current timber inventory of the SYU.

This technical note is designed to outline the methodology for making an economic evaluation of a proposed silvicultural prescription through the use of the U.S. Forest Service Investment Analysis Computer Program (IVST)[1]. The illustration described is a precommercial thinning (PCT) at age 20 followed by commercial thinnings (CT's) at 50 and 80 years of age.

Intensive timber management of forest lands, classified principally for timber production, is necessary to meet our nation's increasing need for wood products. The Allowable Cut (AC) Plan for a SYU is aimed toward the conversion of an unregulated, natural forest toward a regulated forest property. This regulation is accomplished by planning for a high level, nondeclining, sustained yield harvest of timber, prompt regeneration, and investments in various silvicultural treatments which will result in increased timber production. A sample investment analysis problem (Problem #1) is explained step-by-step and executed through the IVST program. Present net worth, benefit/cost

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[1]A Computer Program for Evaluating Forestry Opportunities Under Three Investment Criteria: Daniel E. Chappelle, USDA, Forest Service, Research Paper, PNW-78, 1969.

ratio, and internal rate of return reports are produced by the computer program. A second sample problem (Problem #2) is executed for the purpose of explaining a sensitivity test procedure. Only one of the input variables (mature timber value) is altered in Problem #2. The analyst can use this same methodology to test the reaction of any one of the input variables under different rates of interest.

I. INTRODUCTION

A. The Scope of BLM's Forestry Program

The Bureau of Land Management (BLM), an agency of the U.S. Department of the Interior (USDI), has management responsibilities for 451 million acres in the 11 Western States and Alaska. Approximately 14.6 million acres are classified as commercial forest land and 65.8 million acres are categorized as noncommercial (woodland) forest lands.[1]

1. Commercial Forest Land

Commercial forest lands managed by the BLM are subdivided into three separate and distinct categories. These are:

-- Pacific N.W. Coastal Douglas-fir Rainforests (2.0 million acres). These are generally recognized to be one of the nation's most productive and valuable commercial forest properties.

-- Alaska's Interior Boreal Forests (12.5 million acres).[1]

-- Central and Northern Rocky Mountains, California, and Eastern Oregon Public Forest Lands (2.1 million acres).

2. Noncommercial Forest Land

The Bureau's noncommercial forest lands comprise two major ecotypes. These are (1) Alaska's subarctic forest land and (2) the pinon-juniper forest type located primarily in the Southwestern States. Several million acres of miscellaneous forest types, consisting of Southwestern U.S. chapparal-oak brushfields, streamside and swampy willow bogs, isolated pockets of timber in canyons and on steep rocky slopes, remnant fingers of sparsely stocked acreages of commercial species extending outward into submarginal habitat zones and scrub forests in high elevation (upper timberline) zones, are also found on BLM lands.

B. Legislative History

Numerous legislative acts, regulations, policies and directives governing the management of these forested lands have been enacted or developed. The Code of Federal Regulations (CFR-43; Public Lands, Interior) defines and codifies these statutes and policies in detail.

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[1]U.S. Department of the Interior Public Land Statistics 1979. Conveyance of selected lands to the State of Alaska under the Alaska Statehood Act and to Alaska Natives and Alaska Native corporations under the Alaska Native Claims Settlement Act has recently reduced the BLM commercial forest land base to approximately 5.46 million acres. Additional selections will further reduce the BLM forest acreage.

1. Federal Land Policy and Management Act

The Federal Land Policy and Management Act of 1976 (FLPMA), Public Law 94-579, 94th Congress, establishes public land policies and guidelines for the administration, protection, development, enhancement, etc., of the public lands and the natural resources thereon. One of the Bureau's goals and objectives (FLPMA, Section 102, Declaration of Policy) is "that the management of lands and resources follow the principles of sustained yield and multiple use, unless otherwise specified by law."

Therefore, productive forest land, unless dedicated to some other multiple-use purpose through official action, must be managed under the principles of sustained yield.

Sustained yield is defined as a policy which requires achievement and maintenance in perpetuity of a high level, evenflow (undiminishing output) of renewable resources (wood fiber) from a sustained yield unit (SYU) consistent with multiple-use concepts, ecological principles and environmental concerns.

On June 12, 1979, the President directed the Secretaries of Agriculture and Interior to update land management plans on selected BLM land with the objective of increasing the harvest of mature timber through departure from the current nondeclining even-flow policy if certain conditions are met. The new policy allows for a temporary increase in the harvest level by accelerating the cutting of overmature timber up to, but not above, sustained yield capacity, and then reducing down to, but not below, the harvest level under the even-flow policy.

2. O & C Act of 1937

The Act of August 28, 1937 (50 Stat. 874) relates to the administration of the Revested Oregon and California Railroad and Reconveyed Coos Bay Wagon Road Grant Lands in Oregon, generally referred to as O & C lands. Regulations relating to O & C lands are also found in Title 43, Code of Federal Regulations, Chapter II, Bureau of Land Management.

C. Management Goals

In helping the American people achieve the most effective use of natural resources, energy, and knowledge in the pursuit of their goals, the Bureau has developed a planning system for providing direct inputs into the land-use decision making process. The multiple resource use plan, developed for each management unit considers technical, social, environmental, and economic criteria. The planning system is described in BLM Manual Sections 1602 to 1608 inclusive.

To meet the needs of the American people, as defined in the various legislative acts, particularly the O & C Act, the General Land Office (GLO) developed the first BLM forest management program. The BLM was formed under Executive Order #3 during the Executive Reorganization of June 6, 1946, which combined the General Land Office and the Grazing Service within the Department of the Interior. The forestry program has been continually updated and improved since it was initiated.

The forestry program includes: forest inventory, allowable cut planning, timber management planning, timber measurements, timber disposals, free use of forest products, silviculture, forest development, forest protection, and special studies and research. Detailed guidance of the forest management program may be found under Section 5000 of the Bureau Manual System.

D. Economic Analysis

An economic analysis is required of individual segments of the Bureau's timber management program if the objectives of (1) multiple use, (2) high level, nondeclining, even-flow timber production (sustained yield), (3) environmental quality, and (4) economic feasibility are to be accomplished. Please refer to BLM Manual 9520 for policy and guidance in developing an economic analysis.

1. Technical Note Series

This is the third of a series of reports titled "An Economic Analysis Series for Screening Proposed Timber Management Projects."[1] They are designed to:

-- Explain the reasoning, methodology, and techniques of the evaluating procedures on a step-by-step basis.

-- Maintain a consistent system for evaluating all types of projects, so that they can be rated as to productivity on the same basis.

-- Provide a system for ranking projects in their order of economic efficiency in relation to the production of additional timber.

In evaluating the economic efficiency of a proposed silvicultural treatment of forest stands, the forester must be able to specify and quantify economic consequences of a request for an expenditure of public funds.

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[1]Preceding issues of this series Report No. 1, Technical Note No. 309 (TN309) and Report No. 2, Technical Note No. 323 (TN323) are available from BLM, Bldg. 50, DFC, D-470, Denver, CO, 80225. Refer to the TN number when requesting these publications.

A more complicated type of problem is discussed in this publication than in the two previous TN series. The sample problems (Chapters VIII and IX) show that a loss in income is generally incurred during the year that thinnings are harvested because low value thinned timber replaces higher value mature timber as a portion of the allowable cut (AC). Adjustments in the reforestation program may also be necessary because thinnings are made in place of final harvest of old growth timber. Under the sustained yield even-flow concept, the AC level remains constant. Increased timber yield anticipated from a silvicultural proposal is prorated over life of the investment period in the form of an increased annual AC.

a. Technical Notes #309 and 323 (Reports No. 1 and 2)

The overall economic aspects of timber management investments discussed in Reports No. 1 and 2 cover general investment considerations, multiple-use benefits and costs, interpretational procedures, discount equations and the ranking of investment opportunities.

Report No. 1 (TN 309) and Report No. 2 (TN 323) are concerned principally with general economic analytical considerations of intensive forest management. They also include a system for making a comparison evaluation of the costs and benefits obtainable from precommercially thinning (PCT) overstocked stands of lodgepole pine growing on low site index 40 (TN 309), and higher site index 60 forest land (TN 323). A method for screening silvicultural proposals is provided by showing the benefit/cost and present net worth values under different rates of interest.

Most of the general assumptions of making investments in natural resource projects, are not repeated in this publication. The reader is urged to review Reports #1 and #2, along with Bureau Manual 9520, Economic Analysis, before entering into a detailed economic analysis of proposed silvicultural treatments.

b. Report No. 3

This report (Report No. 3) deals with a timber stand prescription of a direct cost item (PCT) followed by two income-producing commercial thinnings (CT). Each of these actions involve estimated future values and time periods. The proposed silvicultural prescription and the values generated are shown by sample problems in Chapters VIII and IX.

This report is also concerned with the operation of the Bureau's Investment Analysis Data Processing Program, IVST, and the ACE (see part E, next page).

The sample problems are used to develop a sensitivity analysis in tabular and graphic form. A sensitivity analysis can be made for differences in the bid price value of mature timber and thinned timber, PCT costs, timber sale costs, reforestation costs, etc. The only value that is varied in the sample problems shown in Chapters VIII and IX is the value of mature timber stumpage.

2. The IVST Program

The Bureau's IVST program has been made available to all field offices under the Honeywell 66/80 Time Sharing System (TSS). The job control language and the methodology for using the IVST program from a remote terminal is covered in both this report and Technical Note No. 348 "Computer Programs for Use by Forest Managers." All State Office and District personnel should be informed of the availability of the Investment Analysis Program for use in analyzing other types of projects such as water retention structures, range forage values, wildlife habitat improvement projects, etc.

The user may substitute other projected values such as forest fertilization into the silvicultural prescription instead of PCT. Thus, the methodology described can be used to encompass a wide variety of forest practices.

E. The Allowable Cut Effect

1. Future Yields Projections

Timber yields and values from a treated stand may be compared directly to the yields and values anticipated from this same timber stand--had it been allowed to grow to maturity without the application of the silvicultural treatments. Comparisons may also be made between two forest properties, one of which contains treated acreage while the other remains wholly untreated.

2. Allowable Cut Effect

An immediate increase in the planned harvest level of a sustained yield forest, due to a higher future yield anticipated as a result of planned intensive forest management practice, is termed the "allowable cut effect" (ACE). The ACE is a phenomenon that can occur if certain forest conditions, such as an abundance of overmature timber, exists.

The only way to definitely determine the extent of the ACE of a proposed intensive timber management project is to execute the AC forest simulation model (SIMIX 1/) both with and without the proposed project.

A technical note tentatively titled "The Detailed Operation of the Bureau's Intensively Managed Forest Simulation Model," is being drafted and is scheduled for printing in early FY 83. It describes the modeling system and explains the computation of alternative harvest levels.

Timber attributes such as age class distribution, existing volume of mature timber, condition of immature age classes, and management decisions such as utilization standards, regulatory period, reforestation lag, etc., must also be examined by the analyst. All, a portion of, or none of the increased yield attributed to the silvicultural treatment may be applicable to an immediate increase in the annual harvest level computed.

The AC plan is especially critical because it combines silviculture with business economics. Whenever actual work accomplishments in reforestation, PCT, or CT, fall behind the planning phase and the AC volume is still being harvested, the timber-volume-account is being overdrawn, because planned increases in the growth account are not being obtained. An overdrawn timber account must face a correctional process, otherwise the BLM's nondeclining, sustained yield policy is not being followed.

Other forest management agencies follow the concept that cashing in on ACE volume credit is valid only after the intensive management practice is actually carried out on the ground because of the uncertainty of accomplishing planned efforts.

The Bureau's position has been that the decadal AC plan involving reforestation, intensive management practices, and timber harvesting is a public commitment that will be achieved unless catastrophic changes occur. The four-year budget authorization plan is also aimed at providing a level of funding and work months to meet long-term projects. BLM Manual, Section 5240, "Allowable Cut Planning" describes the Bureau's policy concerning timber management, planning, harvest scheduling, etc.

1/ SIMIX is the acronym for Simulating Intensive Management of Mixed Harvest Systems and refers to the BLM's computerized forest modeling system.

II. INTENSIVE FOREST MANAGEMENT

It is generally assumed that intensively managed timber stands and forests will offer greater total returns and better opportunities for greater production rates of high quality, high value timber than extensively managed stands. Non-intensively managed forests, and even irresponsively or haphazardly managed timber stands and forests may also furnish an immediate and substantial return on timber growing investment to the Land Manager as long as a substantial acreage of mature and overmature timber is present.

As nature's store of old growth timber is reduced, the influence of young growth management and the investments involved require more sophisticated methodology in developing systems for forest inventories, silvicultural prescriptions, timber appraisals, and the economic evaluation of alternative management decisions.

A. Stocking Control

Forest managers fortunately have a number of possible management options to follow in their handling of overstocked timber stands. These options may range from a hands-off (extensive management) policy to a full scale complement of cleaning, weeding, spraying, fertilizing, and periodic thinning of the principal stand.

B. Silvical Characteristics of Typical Species

Stands of Douglas fir and ponderosa pine, principal species on Public Lands, are subject to intensive competition between individual trees, but dense stands are not as prone to stagnation as are lodgepole pine stands. Ponderosa pine on very low sites does, however, tend to form stagnated stands at an early age. Healthy stands on higher site quality soils will respond to thinning quickly if their crown length exceeds 40% and their recent radial growth increment does not show extreme stress. Trees on very high site quality soils express their dominance at an early age, crowd out their competing neighbors more easily, and generally show less of a response to a low thinning than do the selected crop trees on medium and poor site areas.

1. Response to Competition

Unlike lodgepole pine, where age is a critical factor, Rocky Mountain ponderosa pine, Douglas fir and Engelmann Spruce will respond to thinning even at advanced ages. Older stands (30-90 years of age) which still remain in the pre-commercial size class category may be assigned a physiological age nearer their actual size class age when scheduling treatments. Refer to BLM Silvicultural Manuals by Species,

BLM Section 5600, for details concerning silvicultural response to treatments. These Manuals also contain recommendations for desirable growing stock levels, stand and stocking projections, height and diameter projections, and other data necessary to develop site specific prescriptions.

2. Prescription Variables

In this report we have assumed the existence of a 20-year old overstocked stand. Several silvicultural prescriptions for this theoretical stand have been developed. Some of the variables considered on these trial and error prescriptions are:

1. The site quality of the average acre to be treated in the SYU with this regime.

2. The timing of the first stand entry for weeding, cleaning, PCT, etc.

3. The size of the cut and leave stems.

4. The level of the cut and the reserve number of stems per acre, basal area, etc.

5. The volume of the cut stems and residual stand.

6. The minimum volume per acre harvestable for a viable, economic logging show.

Only one prescription was adopted for inclusion in this study. The analysis shown by the sample problems (Chapters VIII and IX) is based upon differences in the value of timber offered for sale.

An analysis could just as well have been made of the differences in economic efficiency between two silvicultural prescriptions proposed for the same acreage.

C. Data Reliability

An investment analysis is only as good as the growth and yield projections developed by the silviculturist. Understanding the silvics of individual trees and stands of trees growing in close competition with each other is a critical phase in providing dependable data as inputs into the IVST program. Without some type of growth response to a silvicultural action, there could not be a positive benefit/cost ratio.

Because of the logarithmic character of compound/discount formulae, time becomes a critical function in long term forestry investments. Under compound interest criteria, interest on the principal earned the first year accrues earned interest the second year, etc. For example, if $1.00 is placed in an account now (at a 10% rate of interest) and no other deposits are made:

(a) At the end of the first year the account would contain $1.10.

(b) At the end of 25 years the account would contain $10.83.

(c) At the end of 50 years the account would contain $117.39.

(d) At the end of 100 years the account would contain $13,780.61.

(Refer to Technical Note No. 309 for a discussion of compound-discount equations and their use.)

The use of inflated interest rates for long-term investments can become an academic exercise. The meshing of the above logarithmic characterics with forest growth responses, administrative costs and anticipated income can give apparently biased returns in favor of short-term projects.

D. Management Opportunities

Foresters responsible for the management of the Bureau's forests must consider numerous opportunities to practice intensive silvicultural management of productive forest lands in order to increase the nation's supply of renewable wood resources.

Investment of public funds in the management of young forest stands requires a thorough insight of the consequences of these actions. The silviculture of each species, national resource policies, society and industrial needs, environmental concerns, financial constraints, manpower limitations, and local policies must be meshed into the planning concept of project analysis.

Either action or non-action, by the forest manager, will have an effect upon the quality and quantity of timber production for up to a century or more. Very few other professionals have such long range objectives, or must wait as long to reap the harvest of their initial regeneration efforts. A current forest plantation may not be final harvested for 50 to 100 years hence. Consequently, conflicts often arise involving the philosophies of short-term versus long-term viewpoints concerning the benefits and costs of proposed management alternatives.

It is beyond the scope of this technical note to discuss the pros and cons of accelerated harvest, withdrawal of productive forest lands for wilderness or recreational purposes, discount rates, or subsidized investments for the production of a future timber supply.

When an intensively-managed timber stand is commercially thinned, relatively small size, low value timber is offered for sale. When a forest is being managed for an even-flow of timber harvest or wood fiber volume, it may be necessary to substitute thinning volume for final harvest timber volume. Therefore, during the years that the thinning volume is harvested, less high value, old growth timber is offered for sale in order to maintain the even-flow concept. During other years, the increased allowable cut that is generated by thinnings or other silvicultural treatment, is made up of old growth volume. In addition, if costly reforestation efforts are a normal occurrence, a reduction in reforestation costs will occur during the year that thinnings are harvested.

Because of the significant differences in sale preparation and administrative costs, and of the value received from the two different types of timber products, a more involved analysis procedure is used in evaluating CT's than is used in evaluating artificial regeneration or PCT-only prescriptions.

E. Prescription Design

The sample prescription used in this publication is a simulation of the treatment of a hypothetical field condition. Volumes shown on the stand prescription forms have been rounded to the nearest hundred board feet so that the mechanics of the process can be followed more easily.

In order to provide a base for evaluating the effects of intensive silvicultural inputs, we must compare the result of the thinned stand to the results that would have been obtained had the stand remained in a natural (wild) untreated condition. Numerous publications are available which show projection techniques and explain computerized program systems for developing growth and yield inputs.

The District Silviculturist must develop individual timber stand prescriptions. These will consider local conditions of: species composition, site quality, stand age, product marketability, etc. Stand prescription procedures developed by Bob Alexander and Cliff Myers, USFS, Rocky Mountain Forest and Range Experiment Station, were used by the author for the sample prescription. The "Prognosis Model," a computerized program for projecting growth and yields under various treatments, written

by Al Stage, Intermountain Forest and Range Experiment Station, Moscow, Idaho, will soon be operational on the DSC Honeywell computer. It is applicable to Idaho, eastern Washington and Oregon and western Montana. Other simulation models may be available for use by other states.

When developing a prescription, the forest stand is treated as a system. Each individual tree is viewed as a subsystem with diameter, height, basal area, volume, and increment components which vary in relation to total age, site quality and stand density. In the economic analysis phase, one acre is treated as an entity. Cost and income data, based upon one thousand board feet (MBF) are converted to a per-acre basis.

Investment analysis figures are computed using the additional costs encountered in treating the acre and the additional values anticipated from the increased productivity of that acre.

The choice of a management regime involves silvicultural, financial, environmental, industrial, social, and economic constraints. The sample problem used in this report is an arbitrary selection and the results shown may not coincide with local proposals. Its use should be accepted only as a sample to demonstrate the with-without concept of economic analysis. Start with generating yields expected without any proposed treatment. Then compute yields anticipated from the treated stand. The gain in yield from the treatment must be assigned a value based upon stumpage prices.

Under the minimum base level of forest management, the forest manager must plan upon obtaining adequate regeneration after final harvest of the overstory. Otherwise timber removal without replacement and not sustained yield management is being practiced. Normal regeneration of harvested forest land is not an intensive forest management practice. However, accelerated reforestation, which reduces the normal regeneration lag period, can be considered an intensive management action.

III. INVESTMENT CRITERIA

All three investment criteria, (1) present net worth (PNW), (2) benefit/cost (B/C) ratio and (3) internal rate of return (IRR) must be used to fully analyze the merits of a proposed investment. Rigid use or dependence upon only one of these criteria may give an erroneous answer or mislead the judgement of the investment manager.

A. Present Net Worth (PNW)

All present and future costs and incomes are discounted back to the present using standard discount equations and the desired interest rate. Costs and incomes are thus directly comparable at one point in time.

B. Benefit/Cost (B/C) Ratio

The B/C is a mathematical expression of the PNW of all benefits divided by the PNW of all costs. B/C analysis should be used for all projects where the interest rate (discount rate) is mandated by law or regulations. All projects which include multiple-use resource impacts which affect costs or yields must also be analyzed under this criteria. Individual multiple-use values and costs must be compiled; then each must be reduced to a common denominator (PNW) under approved discount rates of interest. The above compilation may prove to be difficult without specific guidance from the forest manager.

C. Internal Rate of Return (IRR)

The internal rate of return is the rate at which the investment increases toward the return it finally generates. The equation for computing rate of return (i), for an investment cost (c), which yields a return value (R), is:

$$c(1 + i)^n = R$$

1. Standard Computation

For example, compute the IRR of a PCT, at a cost of $100 per acre, that yields an additional harvest volume of 8.0 MBF per acre, worth $120.00 per MBF, when harvested 60 years from today. Solve for (i) when the cost and returns are known. See TN 309, Equation No. 2, page 13. This is not an ACE computation.

$$100(1 + i)^{60} = \$960$$

$$(1 + i)^{60} = \$9.60$$

$$i = 0.0384 \text{ or } 3.84\%$$

This 3.84 percent interest rate represents a one-time, future harvest value discounted back to the present. The future value is stated in today's prices; inflationary rates are not considered.

2. Allowable Cut Effect (ACE)

Under the allowable cut effect analysis, the extra 8000 board feet (bd ft) produced, at harvest time, through intensive management practices would be used to replace a like volume of old growth timber, harvested annually over the next 60 years. Assume that the full increment can be utilized under the ACE concept.

Annual Increase in Cut:

$$\frac{8{,}000 \text{ bd ft}}{60 \text{ years}} = 133.333 \text{ bd ft annually}$$

Annual Additional Income for 60 years

= $120.00 x 0.13333 MBF

= $16.00 in extra income annually for every acre that is thinned.

Solve for (i):

Use Discounted Annual Payment Equation
(See TN 309, Report No. 1, Equation No. 6, p. 14.)

$$\$16 \frac{(1 + i)^n - 1}{i(1 + i)^n} = \$100.00$$

$$\frac{(1 + i)^n - 1}{i(1 = i)^n} = 6.250$$

$$i = 0.160$$

$$i = 16\%$$

Thus, by taking advantage of the thinning results immediately, a 16-percent return can be credited to the thinning investment under the ACE concept. Otherwise, if the age class and volume distribution are such that the thinning projects will have no impact upon the AC, a 3.84-percent rate of return can be credited to the thinning investment.

3. IRR Precautions

The IRR is a valid figure for evaluating the acceptance or rejection of a project; however, the decision to invest may depend upon the rate of discount being used. Only by using the approved discount rate for water and land resources investments can we calculate a correct, unambiguous, present net value which can be used to evaluate the proposed investment. The time elapsed between costs and incomes also affects the process of distributing consumption over time. Two projects with the same IRR may show significant different PNW values when future incomes are obtained during different time periods.

4. Discount Rates

The U.S Forest Service has recently been instructed to use a 4% real rate of return for forestry investments analysis.

As a result of Executive Order 12291, the OMB ("Interior Regulatory Impact Analysis Guidance," June 12, 1981) directs the Department of the Interior to use a 10% discount rate when examining the economic effect, in constant dollars, of proposed regulatory rule-making.

The "Water and Related Land Resource Council" periodically publishes a discount rate to be used for long-term land and water investment analysis.

The BLM Director prepares periodic Instruction Memoranda of approved discount rates to be used in analyzing proposed natural resource investments.

IV. QUESTIONS AND ASSUMPTIONS

Listed below are some of the questions which must be adequately answered before requests for public funds for timber management can be honored.

- What would the biological yield of a stand be under different levels or intensities of stand management?

- What is the effect of site quality upon the increased yields anticipated from intensive stand management?

- What is the B/C ratio, the PNW, and the IRR for carrying out a timber stand improvement project?

- What is the effect of (1) site quality, (2) varying interest rates, (3) thinning costs per acre, (4) prices received for timber, and (5) the timing of costs and income in computing the B/C ratios of various stand improvement proposals?

A. General Assumptions: The following assumptions set the stage and delineate the boundaries within which other technical decisions must be made in the sample/example problems.

-- Sufficient mature and overmature timber exists in the unit to allow the use of the direct impact approach or ACE of analysis of timber production investments.

-- The ACE may be applied immediately. Harvest credit, anticipated as an increased yield at maturity or in intermediate cuts from the treated stand, may be applied annually to mature timber anywhere within the SYU.

-- The with-or-without concept of incremental benefits derived from the proposed treatment should be used.

-- Fixed costs, such as for protection and general administration, will not be affected by the treatment.

-- Present-day costs for precommercial thinning vary from $25.00 per acre (for walking through with a tractor) to $200.00 or more per acre for hand-thinning dense, overstocked stands. A figure of $100.00 per acre is used in the sample problem.

-- All administrative costs for putting mature and overmature timber up for sale (i.e., planning, layout, cruise, contract administration, etc.) vary from $5.00 to $25.00 per MBF.

-- A benefit/cost ratio of less than 0.50 from timber income, as expressed from the following equation,

$$\div \frac{\text{Present value of benefits}}{\text{Present value of costs}} = \text{B/C Ratio}$$

usually cannot be considered a primary timber production project because other multiple-use purposes would have to carry the majority of the load to make the investment financially attractive.

-- Timber producing investments such as thinnings which meet or exceed a B/C ratio of 1.0, from timber benefits alone, may be ranked as financially attractive for their timber production capabilities.

-- Forest managers may be limited by budget constraints, policies, work months and the combination of costs and benefits of other multiple-use disciplines, in the final ranking of proposed projects. The final ranking must contain timber, plus all other multiple-use benefits and costs.

-- All disciplines must reduce their data to a common denominator (base) for use in analytical comparisons. Where this methodology is not available, the direct impact approach to timber production may be the only data available. For example: A 100% scenic view exclusion would reduce the forest yield by "X" number of board feet worth "Y" dollars in foregone income, employment, services, etc.

-- Income from the disposal of public domain timber varies from $2.00 per to $200.00 or more per MBF. The multiplier effect of producing finished products from forest stumpage varies from 10 to 25 times the value of standing timber.

-- The bid price for public domain timber may or may not reflect sizeable investments in capital improvements such as public access, roads, bridges, reforestation, etc.

-- The examples of forestry investment in this technical note describe only the direct timber values received. Volume increments must be saleable or marketable under authorities listed in BLM Manual 5400, Timber Sales.

B. Uncertainty of Results

Most forest projects involve a risk of partial failure (e.g., plantation survival is seldom, if ever, 100% successful). Rather than build in a risk factor, success ratio, percentage of certainty, or some other adjustment factor for the sample problems being analyzed, a 100-percent rate of success has been elected to be used in the sample problems, Chapters VIII and IX.

The analyst can use the sensitivity procedures, (increased cost data or reduced benefits) to handle the problem of partial success of the project (see Chapter X). Average risk factors and their standard deviations may also be presented in graphic or tabular form when developing priority listing of competing projects.

C. Project Size

For analytical purposes, all data is reduced to a per acre basis. It is obvious that planting or thinning one acre of a 120,000-acre forest is irrelevant to the overall forest operation. The maximum size of a proposed project area is a function of physical, biological, administrative, fiscal, and managerial restraints. The minimum size project area should be a local, on-the-ground decision by the area manager. The important consideration is, does the additional investment pay for itself?

D. Project Approach

Assuming that the costs and benefits of business-as-usual are available, what is the economic feasibility of investing in an intensive timber management regime for a portion of the forest acreage? Actions of the forest manager should not be treated as individual entities. Many of the decisions now being made will have a direct bearing on the forest and its components 50 to 100 years or more from now. Decisions based on an inadequate or faulty set of data have a greater chance of missing the intended results than those from a good data base.

V. EXISTING FOREST INVENTORY DATA

A "fabricated" forest inventory unit contains a sizeable acreage in the 10-, 20-, and 30-year age classes. Stand densities range from poorly stocked to heavily overstocked.

Some of the overstocked stands are comprised of Ponderosa pine, Douglas fir, and Lodgepole pine, which would respond well to intensive stand management. A review of access, topography and biological attributes of overstocked young growth acreages indicates that a PCT at 20 years of age, followed by one or more CT's would substantially increase recoverable timber volume from these stands.

To evaluate paired projects or proposals which follow the "with or without" management regime, we must assume that an ongoing forest management program is in operation and that a store of knowledge about the resources involved is readily available.

The sample analysis uses a theoretical BLM Public Domain District as a base. Assume that the following data has been extracted from the recent public domain extensive forest inventory and AC computational data.

A. Forest Acreage

1. The SYU contains 120,000 acres of productive forest land available for timber production.

2. Sixty thousand (60,000) acres are mature (100 years of age) or older.

B. Mature Timber Volume

1. The unit contains 720,000,000 bd ft of merchantable timber on the acreage classified as mature timber.

2. The average volume per acre of all of the stands classified as 100 years and older is:

$$\frac{720{,}000{,}000 \text{ bd ft}}{60{,}000 \text{ acres}} = 12{,}000 \text{ bd ft/acre}$$

C. Allowable Cut Computations

1. The allowable cut computations show that the age class and volume distribution are such that 100 percent of any increase in volume produced from thinning projects can be used to increase the annual AC. One-half of the forest acreage supports stands of mature or overmature timber.

2. Assume that the forest management program is currently being operated at a "base zero" level, which is equivalent to a "without" level of intensive management.

3. One hundred million board feet (100 MMBF)[1] can be harvested per decade without violating the principles of even-flow, non-declining, sustained yield policy constraints. The annual cut would be 10 MMBF.

D. Silvicultural Projections: The following silvicultural projections have been made.

1. Second generation untreated timber stands will yield 13,500 bd ft at 100 years of age, as shown on the attached yield table, Table I, page 20. This yield projection is for site quality 50 forest acreage (50-year site index base).

2. The total production from thinned stands on site index 50 forest land will be 24,000 bd ft/acre at 100 years of age (refer to Table II, page 21). This volume includes 7,500 bd ft harvested as intermediate thinnings.

3. The increased volume due to thinning an existing 20-year old stand is 10,500 bd ft/acre at 100 years of age, which translates into an annual increase in the AC of 131.25 bd ft for every acre thinned when using an 80-year investment period. Refer to Table III, page 22, for yield table comparison figures.

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[1]Roman numeral "M" is the traditional symbol for one thousand. MMBF is the abbreviation for thousand thousand (million) board feet of timber.

TABLE I

YIELD PER ACRE OF EVEN-AGED NON-INTENSIVELY MANAGED STANDS OF LODGEPOLE PINE

SITE INDEX - 50 yr. base 50
100 yr. base

FORM CLASS = 75

STAND AGE (YEARS)	NUMBER OF TREES PER ACRE	AVERAGE D.B.H. (INCHES)	AVERAGE HEIGHT DOMINANT STAND (Ft)	BASAL AREA IN SQ. FT. PER ACRE	VOLUMES			PERIODIC CUT					TOTAL YIELD		
					Int. 1/8" BOARD FEET PER TREE	MERCH. CU. FT.	TOTAL VOL. PER ACRE BD. FT.	NUMBER OF TREES PER ACRE	BASAL AREA PER ACRE	TOTAL CU. FT.	MERCH. CU. FT.	SAWTIMBER BD. FT.	MEAN ANNUAL INCREMENT	MERCH. CU. FT.	SAWTIMBER BD. FT.
0	0	0.0	0	0											
5	2500	0.0	1	0											
10	1000	0.1	5	0											
15	900	1.3	13												
20	800	2.5	20	28											
30	700	4.0	32	61											
40	660	5.3	42	101	4.0		2500								
50	640	6.2	50	134	10.2		5000								
60	630	6.8	56	158	16.1		7500								
70	620	7.2	61	175	21.1		10000								
80	615	7.3	64	179	23.1		12000								
90	610	7.4	67	182	25.1		13000								
100	605	7.5	69	185	26.9		13500						135		13500
110	600	7.6	70	189	28.4		14000								
120	595	7.7	70	192	29.7		14500								

Assume adequate regeneration at 20 years of age.

TABLE II

PRECOMMERCIAL THINNING FOLLOWED BY COMMERCIAL THINNING

STAND PRESCRIPTION

YIELD PER ACRE OF MANAGED EVEN-AGE STANDS OF: LODGEPOLE PINE

SITE INDEX - 50 yr. base 50
100 yr. base ____

FORM CLASS = 75

STAND AGE (YEARS)	NUMBER OF TREES PER ACRE	AVERAGE D.B.H. (INCHES)	AVERAGE HEIGHT DOMINANT STAND (Ft)	BASAL AREA IN SQ. FT. PER ACRE	VOLUMES			PERIODIC CUT					TOTAL YIELD		
					Int. 1/8" BOARD FEET PER TREE	MERCH. CU. FT.	TOTAL VOL. PER ACRE BD. FT.	NUMBER OF TREES PER ACRE	BASAL AREA PER ACRE	TOTAL CU. FT.	MERCH. CU. FT.	SAWTIMBER BD. FT.	MEAN ANNUAL INCREMENT	MERCH. CU. FT.	SAWTIMBER BD. FT.
0	0	0.0	0												
5	2500	0.0	1	0											
10	1000	0.1	5	0											
15	900	1.3	13	8											
20	800	2.5	20	28											
PCT												000			
20	475	3.0	20	23											
30	465	5.0	32	63	1.0	2.00	500								500
40	455	6.3	42	98	9.8	3.90	4000								4000
50	445	7.1	50	122	17.3	5.32	7500								7500
CT												2500			
50	275	7.3	50	80	19.1	5.6	5000								7500
60	265	8.4	56	102	32.4	7.8	8500								11000
70	260	9.3	62	123	47.3	10.3	12000								14500
80	260	10.0	66	142	60.9	12.4	15000								17500
CT												5000			
80	173	10.0	66	94	60.9	12.4	10000								17500
90	168	11.0	69	111	81.2	15.5	13500								21000
100	165	11.9	72	127	102.8	18.8	16500								24000
110	165	12.7	74	145	123.6	21.9	19500								27000
120	165	13.4	75	161	142.4	24.7	22500								30000

TABLE III

Yield Table Comparisons
Mixed Conifer: Site Index 50 (50-Year Base)
Unmanaged vs. Thinned Stands

AGE CLASS IN YEARS	Not Thinned	Thinned Stands				Difference Due to Thinning	Allowable Cut Effect	
		PCT @ 20 Yrs. + CT @ 50 Yrs. + CT @ 80 Yrs.						
	Natural Stand Bd Ft Per Acre	Thinned Volume Bd Ft Per Acre	Standing Volume Bd Ft Per Acre	Total Production Bd Ft Per Acre	Mean Annual Increment Bd Ft Per Acre	Bd Ft Per Acre	No. of Years Affected	Increase In Annual Cut Bd Ft
20	0	0	0	0	0.0		0	
30	1		1500	1500	50.0	1500	10	
40	2500		4500	4500	112.5	2000	20	
50	5000	2500	5000	7500	150.0	2500	30	83.33
60	7500		8500	11000	183.3	3500	40	87.50
70	10000		12000	14500	207.1	4500	50	90.00
80	12000	5000	10000	17500	218.8	5500	60	91.67
90	13000		13500	21000	233.3	8000	70	114.29
100	13500		16500	24000	240.0	10500	80	131.25
110	14000		19500	27000	245.0	13000	90	144.44
120	14500		22500	30000	250.0	15500	100	155.00
130	15000		25000	32500	250.0	17500	110	159.09
140	15500		26500	34000	242.9	18500	120	154.17

Refer to Tables I and II, pages 20 and 21.

VI. COST AND RETURN DATA

Care must be taken when discounting costs and incomes back to the present to make sure that the full time frame is used. Costs or incomes are treated as being incurred or received at either the beginning or at the end of the investment year. For example, if an income of $1,000.00 (discounted at 10%) is received at the end of year #1, the present new worth of this future income is $900.00.

The user must determine if the cost or income from each action occurs at the beginning or at the end of the investment period. Under most conditions the investment period is one year. A coding of "yes" in "Initial Cost or Returns," column 50, Item #3E, page 38, indicates that the cost or return occurs at the beginning of the year identified in columns 23-25 of input Item #7 of the IVST computation input form. (Refer to Chapter VII pages 38 and 39 for a copy of the IVST computer input form.)

The IVST computer program cannot accept inputs for both the beginning and the end of the year that is coded. When mixed costs and incomes, which occur at both the beginning and the end of the same year, are being used, choose the "yes" or "no" code on the IVST Form, Item #3E, "Initial Costs and Returns," and Item #3F, "Discounted Costs and Returns." Match input Item #3 to input Item #7, "Beginning in year # _ " and "Ending in year # _ ." Discounting an initial return received at the beginning of year #2 is the equivalent to discounting an entry made at the end of year #1.

The following costs and incomes used in the sample problem are fabricated figures. The assumption made herein is that timber harvest costs and incomes received are stable in relation to all other values.

A. Precommercial Thinning Costs

The cost of precommercial thinning varies from area to area depending upon stand density, size of timber, methodology, topography, size of area, etc.

In the sample computation, an average cost of $100.00 per acre is used.

B. Timber Sale Administrative Costs

The administrative costs for putting mature and overmature timber up for sale varies among State and District Offices. Included in this category are planning, sales area layout, timber cruising, access development, timber appraisal, contract preparation, and contract administration.

In the sample computation, an average cost of $10.00 per MBF is used.

C. Bid Prices for Mature Timber

The bid price for timber may include sizeable investments in capital improvements such as obtaining access, road and bridge construction, rocking, fencing, reforestation, etc.

In sample problem #1 a stumpage value of $200.00 per MBF is used for mature (old growth) timber harvested in the District. Note that the stumpage value includes the average bid price received plus the required investments in capital improvements. In sample problem #2, $100.00 per MBF is used as the stumpage value for mature timber.

D. Commercial Thinning Cost at 50 Years of Age

The preparation of a thinning sale, in an immature 50-year old timber stand, requires considerably more labor per MBF than is consumed in offering mature timber for sale.

In the attached sample this administrative cost is projected to be $20.00 per MBF or $50.00 per acre since 2,500 bd ft is being harvested.

E. Income from Thinning a 50-Year Old Stand

The object of thinning a 50-year old stand is to leave 250 to 300 well-spaced trees per acre. The stems removed are generally smaller than average, of poorer form, and least likely to be selected as final crop trees. Consequently, the value of the products removed is relatively low.

A value of $50.00 per MBF is placed upon the volume removed during this thinning. An income of $125.00 per acre is received from this thinning operation.

F. Cost to Thin an 80-Year Old Stand

The administrative cost to re-thin an 80-year old stand that has had two previous thinnings, should be approximately the same as for offering old growth for sale. Access is now available, trees are uniformly of good quality and size, ground obstructions should be minimal, etc.

A cost of $55.00 per acre or $11.00 per MBF is used in the sample problem.

G. Income from the Harvest of 80-Year Old Thinnings

The basal area of the stand should have increased to a level where competition is reducing overall growth. Remove approximately one-third of the number of trees (80 to 100 trees per acre), based upon both spacing and tree condition. Five MBF per acre is anticipated from this harvest.

An income of $150.00 per MBF or $750.00 per acre is anticipated from thinning the 80-year old stand.

H. Final Harvesting of Thinned Stand

The value of the thinned stand, when it is available for final harvest at 100 years of age, is projected to be the same as the value of old growth stands even though the trees may be smaller.

A stumpage value of $200.00 per MBF is assigned to the mature stand. At 100 years of age, 16,500 bd ft will be available for harvesting. The volume harvested is used to replace volume already depleted annually over the past 80 years.

If the final harvest value (quality of timber of the thinned stand) is substantially higher than the final harvest value of the unthinned stand, the additional worth (80 years from now) must also be discounted back to the present.

I. Sensitivity Analysis

The IVST program may be rerun several times by using varying individual cost or income values such as defined in Section C (above) in "Bid Prices for Mature Timber." A sensitivity analysis can be made by plotting the PNW and B/C values obtained by using, for example, bid prices of $50, $100, and $200 per MBF for mature timber. An inspection of the graphed data would show how much stumpage values must be for the proposal to be a viable project. Chapter X, page 57, contains a graph of the data developed from sample problems 1 and 2.

VII. IVST: DATA PROCESSING PROGRAM L270

Chapters V and VI contain the forest inventory data, AC data, and timber sale cost and return data needed for an economic analysis. The next step is the preparation of this input data for the execution of the IVST program. It is generally advisable to fill out a set of IVST worksheets prior to data entry. Keypunched data must be stored in the user's temporary or permanent catalog/file space under an arbitrary file name. Turn to pages 38 and 39 for an overview of a completed set of worksheets before continuing with this section.

The input forms (worksheets) contain eight major card format items. Some items contain numerous subsections which must be filled out in the proper line/column format for the program to operate properly and run to a normal termination. Each of the Items and subsections are explained below. Item numbers are located along the left boundary of the worksheets.

Each item and/or subsection is divided into four parts. The explanation of these parts is as follows:

Part 1. Numbered line items consist of the name, the title, or an explanation of the item to be completed. The position (column) and the number of spaces to be filled is also shown. This line is shown underlined. (See P.1., page 27.)

Part 2. The second part consists of a general narrative or instructions for filling in the names, codes, numbers, etc. (See P.2., page 27.)

Part 3. Inputs for the sample problem used in this publication are shown here. Alpha character inputs are always capitalized, and all alphanumeric inputs are shown underlined.

Part 4. Part 4 is also indented and blocked. A detailed explanation, if necessary for the response entered in Part 3, may be found here. This part may also contain the reasoning process for entering the cost and income figures shown under Item #7, page 39.

The following input data (pages 27 through 37 inclusive) is used to develop sample Problem No. 1 as shown in Chapter VIII. The data shown under Part 3 (P. 3.) is recorded on the IVST input forms (worksheets #1 and #2, pages 38 and 39).

Item #1

P. 1. Study Identification: Alphanumeric: 1-72 Characters.

P. 2. Select a unique name for each individual study. Begin the first word in column 1, line 1.

P. 3. PCT and COMMERCIALLY THIN AT 20, 50, and 80 YEARS OF AGE.

P. 4. Each separate study may consist of one or more closely related problems. This card must have an entry, even if it is only one letter or number.

Item #2

P. 1. Problem Identification: Alphanumeric: 1-72 Characters.

P. 2. Select a unique name or number for each individual problem in your study. Place the first letter of the first word in card column 1, line 2.

P. 3. EXISTING LODGEPOLE PINE STAND: 20 YEARS OLD: SITE INDEX 50.

P. 4. A problem may contain up to a maximum of 20 alternative subproblems. Each subproblem may differ from one another by the data that is entered under Item 7. The sample problem used in this technical note contains only one set of inputs.

Item #3A

P. 1. Beginning Interest Rate: NN.NNN: Columns 5-10 Inclusive.

P. 2. Select the lowest interest rate to be tested. A zero discount rate input is recommended for general purpose studies.

The IVST Program can handle negative interest rates for analyzing subsidized or direct cost operations. The rate must be preceded by a negative (-) sign. Subsidized, non-income producing activities are often instigated to prevent deterioration or losses which would be greater than the subsidized cost.

P. 3. 00.000

P. 4. A zero interest rate is used as the beginning level. The PNW of a series of costs or returns, at a zero rate of interest, is the sum of the values entered regardless of the time period involved.

Item #3B

P. 1. Ending Interest Rate: NN.NNN: Columns 15-20 Inclusive.

P. 2. Select the highest interest rate to be tested. Computer time is relatively cheap; do not hesitate to extend the highest interest rate to be tested on the first trial run.

P. 3. 00.350

P. 4. A 35-percent interest rate is used as the highest range to be tested for the sample thinning problem.

Item #3C

P. 1. Interest Rate Increment: NN.NNNNN: Columns 23-30 Inclusive.

P. 2. Select the increments between the lowest and highest rates to be tested. With an increment rate of one percent, a beginning rate of 00.000, and an ending rate of 00.350, 36 tests will be performed for this problem.

P. 3. 00.01000

P. 4. An incremental rate of change of one percent is used in the initial screening. Refinements in the lowest and highest interest rates tested, and in the rate of incremented change per computation can be made after the first computer run is completed. Use the EDIT system to correct or update your IVST input file.

Item #3D

P. 1. Number of Alternatives: NN: Columns 39-40.

P. 2. Up to 20 combinations of inputs may be listed under Item 7 (costs and returns). Record the number of subproblems developed for this problem series in columns 39 and 40.

P. 3. 01

P. 4. Only one test run will be made with the sample data shown in Chapters V and VI. Remote terminal users may wish to make a practice computer run after altering the input data. Sensitivity analysis studies may be made for individual cost or return inputs.

Item #3E

P. 1. Initial Cost or Return: N: Column 50.

P. 2. Record the code for "yes" or "no" depending on whether costs or returns scheduled in Item 7B occur at the beginning or end of the investment period. Code "0" for yes (occurring at beginning) or "1" for no (occurring at the end of the year identified).

P. 3. 0 (yes)

P. 4. The code 0 ("yes") input signifies that the cost of PCT and all other costs and incomes are incurred or received at the beginning of the year identified under Item 7. Note that the computer printout (page 44) shows the costs and returns beginning in year zero (immediately).

Item #3F

P. 1. Discount Cost or Returns: N: Column 60.

P. 2. Record the code for "yes" or "no" depending on whether or not costs and returns are to be discounted back to the beginning of the investment period.

P. 3. 0 (yes)

P. 4. All future costs and returns must be discounted in order to compute the PNW of these values.

Item #4

P. 1. Names of Alternatives: AN: Columns 1-40: 5 Each, 8-Column Segments: 4 Lines.

P. 2. Draft an 8 digit name for each of the subproblems recorded under this item. A maximum of 20 subproblems can be developed under each problem name.

P. 3. PCT=$100 (Maximum of 8 digits.)

P. 4. The abbreviated subproblem is identified as having a PCT cost of $100.00 per acre. Another subproblem could be developed which uses a $200.00 per acre PCT cost. The results of subproblems with different PCT costs could then be plotted on graph paper and a sensitivity analysis made to determine where the break-even point of PCT costs occur under any rate of interest used.

Item #5A

P. 1. Problem Number: AN: Columns 7-10 Inclusive.

P. 2. Pick a 1-4 digit problem number which refers to Item #2, "Problem Identification," page 27.

P. 3. 0001

P. 4. Since only one subproblem is being run for this part of the demonstration, the number 1 was naturally selected.

Item #5B

P. 1. Type of Calculation: N: Column 20.

P. 2. Insert the code for either a terminable or perpetual series of repeatable investments (Code #1 = Perpetual, #2 = Terminable).

P. 3. 2

P. 4. A terminable type of calculation is completed at the end of the investment period designated. If the object of a study, for example, is to plant and harvest, etc., with a 100-year rotation period (for perpetuity), the perpetual code would be used. The impact of the thinning in this TN ends with the final harvest of the thinned stand 80 years from now; thus the investment type is terminable.

Item #5C

P. 1. Investment Criterion: N: Column 30.

P. 2. Insert the code for the investment criteria desired, i.e., (1) IRR, (2) B/C ratio and PNW, or (3) all three criteria.

P. 3. 3

P. 4. Ask for the results of all three computations to be printed. Computer operational time and cost is insignificant.

Item #5D

P. 1. Length of Period, Years: NN: Columns 39-40.
The length of investment period is the time that the funds involved are held before being subjected to another discount (interest) recomputation.

P. 2. Record the length of the investment period for computational purposes. Classical investment analysis are generally based upon a one-year computational period. The methodology for compounding or discounting on a daily, monthly, quarterly, or annual basis is shown in Report No. 1, Technical Note No. 309, page 16.

P. 3. 01

P. 4. The program has been told to use one year as the length of an investment period. If necessary, the program can be modified to handle periods shorter than one year. Discounting of periodic future incomes such as those received from an uneven-age selection harvest management system every 5, 10, 20 or more years is not feasible for projects which have annual administrative and operational costs.

Item #5E

P. 1. Maximum Number of Years in Series: NNN: Columns 48-50.

P. 2. Record the maximum length of the subproblem investment series cited in names of alternatives.

P. 3. 080

P. 4. The examples shown in this publication use an 80-year investment period. Twenty subproblems can be tested during one "run" of the IVST program. Refer to item #6 of the input form for the longest investment period used in any of the subproblems.

Item #6

P. 1. Number of Years in Investment Series For Each Alternative: NNN: 20 Segments of 3 Columns each: Columns 1-60.

P. 2. Each of the subproblems may have a different length of investment period. All subproblems must be either terminable or perpetual as indicated by 5B.

P. 3. 080 (Columns 1, 2, and 3 only)

P. 4. The existing 20-year old sapling size stand in the sample problem will be harvested at 100 years of age; therefore, the investment period is 80 years. At the end of this 80-year period the treated stand will be harvested. All of the extra growth created by the silvicultural treatments has been accounted for by the higher annual cut for the past 80 years. If no further silvicultural treatments are planned, the ACE is cancelled and both forests follow the nontreated harvest level thereafter.

Item #7: Cost and Income Format.

1. Amount.

P. 1. Costs or Returns For Each Year: $NNNNNNNN.NN: Columns 5-15 Inclusive.

P. 2. List all costs incurred before entering any incomes. Costs may be incurred at the beginning or the end of the annual or periodic length of period selected. Correlate Item 7 with Items 3E or 3F and 5D. Costs may be either positive or negative values indicating actual cost (+) or costs foregone (-) in the sub-problem. Next, list all incomes anticipated. Incomes may also be received at the beginning or end of the investment period, and may be positive or negative figures. Use as many page 2's of the form as is necessary to complete the problem.

2. When To Begin.

P. 1. Begin in Year: NNN: Columns 23-25.

P. 2. Indicate the number of the year in which the cost is incurred or in which the income is received.

3. When To End.

P. 1. End in Year: NNN: Columns 33-35.

P. 2. Record the number of the ending year in which the cost or income occurs. A reforestation cost, for example, would be an initial cost that would both begin and end in year #1. Protection costs would begin in year #1 and occur annually to year #80 for an 80-year investment period. A perpetual series would be indicated by coding a "1" in Item 5B.

4. End of Input Code.

Last Entry: N: Column 45.
Code a "0" in Column 45 for all costs except the last. Code a "1" for the last entry line for costs incurred. This notifies the computer program that the next line entry will be an income item. Code the incomes listed in the same manner as designated for costs. Upon finding a "1" in the income column, the computer program is instructed to end the problem and start a new subproblem, if there is one.

5. Sample Problem Input Data (Item 7).
Cost and income data used in sample Problem #1 are listed below as individual line entries. The reasoning behind the values and time periods used is also known. See worksheet #2, page 39.

Line #1: Precommercial Thinning Costs.

P. 3. $100.00 001 001 0

P. 4. The timber stand will be precommercially thinned only once. It will cost $100.00 per acre to eliminate all of the unwanted stems. Note that both discounted and initial costs were coded "yes" under Item 3E. The $100.00 per acre cost, therefore, is encountered at the beginning of year #1. The ADP printout will show the initial cost occurring in year zero. Its discounted value is the full amount of the entry value.

Line #2: Cost to Sell Additional Old Growth.

P. 3. $1.31 001 029 0

P. 4. The increased AC volume (131.25 bd ft) may be harvested from old growth timber anywhere within the SYU annually for the first 29 years. It costs $10.00 per MBF to prepare the extra volume for sale. An annual cost of $1.31 is incurred for every acre that is thinned (0.131 X $10.00).

Line #3: Thinning Costs at 50 Years of Age.

P. 3. $50.00 030 030 0

P. 4. During year #30, the timber stand is 50 years of age and scheduled for its first CT. The cost of this thinning is $20.00 per MBF or a total of $50.00 per acre for the 2,500 bd ft of immature timber harvested from the treated area.

Line #4: Additional Selling Costs for Old Growth Timber.

P. 3. $1.31 031 059 0

P. 4. During years #31 through #59, the 131.25 bd ft of old growth will be sold at an annual cost of $1.31. (This is the same as for Line #2 above.)

Line #5: Thinning Costs at 80 Years of Age.

P. 3. $55.00 060 060 0

P. 4. When the stand is 80 years old, it is scheduled for its second CT. Five MBF will be harvested from this treated acre. Administrative costs of $11.00 per MBF, or $55.00 per acre, have been arbitrarily selected. Use local corrected data for your own problem.

Line #6: Additional Selling Costs for Old Growth Timber.

P. 3. $1.31 061 080 0

P. 4. Between the second thinning (at age 80) and the final harvest of this stand (at age 100), the same yearly costs of $1.31 will be incurred for offering the 131 bd ft of mature timber for sale.

Line #7: Harvest Costs Foregone at Age 50.

P. 3. $-23.69 30 30 0

P. 4. We must assume an even flow, sustained yield harvest level for both theoretical forests. The forest with the thinned acre has an annual AC of of 131 bd ft more than the nontreated forest.

During year #30, 2,500 bd ft of high priority thinnings were sold. The District forester did not have to cruise 2,369 bd ft of old growth (2,500-131) as he normally would have done for the first 29 years in the untreated forest.

A negative or foregone cost is needed to cover the volume substitution concept. At an administrative cost of $10.00 per MBF, a negative cost of $23.69 is incurred during year #30 for the amount of old growth not sold.

Line #8: Harvest Costs Foregone at Age 80.

P. 3. $-48.69 060 060 1

P. 4. During year #60, a similar foregone cost is involved for the 4,869 bd ft (5,000-131) of mature timber not offered for sale. The foregone cost at $10.00 per MBF for mature timber is $48.69.

Note the "1" entered on this line in column #45. The "1" code signifies that this is the last of the cost entries. All following entries in the Item 7 format will be incomes received.

Line #9: Additional Income Received from Old Growth Timber.

P. 3. $26.20 001 029 0

P. 4. The increased AC (131 extra bd ft) generated by thinning one acre will earn an extra $26.20 annually for years #1 through #29. A selling price of $200.00 per MBF includes both cash received and capital investment in access, road construction and other land improvements. Values received for enhancement of multiple-use benefits are not included in this sample problem.

Line #10: Thinning Income from 50-Year Old Stand.

P. 3. $125.00 030 030 0

P. 4. During year #30, 2,500 bd ft in thinnings will be harvested. We have assumed a stumpage value of $50.00 per MBF for the immature timber.

Line #11: Income Forgone During Year #30.

P. 3. $-473.80 030 030 0

P. 4. During year #30, the District has foregone the income it would have received from a nontreated forest through the regular sale of old growth timber. The loss of income from the thinned forest, (2,500-131 bd ft) at $200.00 per MBF is $473.80.

Line #12: Additional Income Received.

P. 3. $26.20 031 059 0

P. 4. The additional income from old growth resumes for years #31 to #59 inclusive. Refer to Line #9.

Line #13: Thinning Income from Stand at 80 Years of Age.

P. 3. $750.00 060 060 0

P. 4. A thinning volume of 5,000 bd ft is anticipated when the stand reaches 80 years of age. A value of $150.00 per MBF is placed upon the thinned volume. Access and transportation systems are available. The previously thinned stand should contain trees of good form and quality; specialty products (poles with less than 6 rings per inch) bring a premium price. A value of $750.00 per acre should be received from this thinning.

Line #14: Income Foregone.

P. 3. $-973.80 060 060 0

P. 4. The 5,000 bd ft in thinnings from the treated forest will replace 4,869 bd ft (5,000-131) which normally would be sold from the untreated forest. This relative loss of income from the sale of old growth at $200.00 is $973.80 for each acre thinned.

Line #15: Additional Income.

P. 3. $26.20 061 080 1

P. 4. The additional old growth volume will be sold annually until the thinned stand is harvested at age 100. All of the increased old growth volume will be replaced by the additional yield produce by the treated stand.

Note that a "1" is coded in column 45 signifying that Line #15 is the last income entry of this problem.

Item #8

P. 1. Code 998 = Do Another Problem: NNN: Columns 1-3 Inclusive.

Code 999 = End of Problem: NNN: Columns 1-3 Inclusive.

P. 2. Select the code to end the problem or continue on with additional problems.

P. 3. 999 (Columns 1, 2, and 3)

P. 4. Sample Problem #1 consists of only one set of inputs. Problem #2, Chapter IX contains a modification of the stumpage value of mature timber only. Other costs and incomes are not updated. The sensitivity analysis section, Chapter X, explains how to test the sensitivity of a change in any one given cost or income value.

WORKSHEET #1

"IVST" INVESTMENT ANALYSIS INPUT FORM

Page 1 of 2

1 STUDY IDENT. (1-72)
PCT AND COMMERCIAL THIN AT 20, 50, AND 80 YEARS OF AGE

2 PROBLEM IDENT. (1-72)
EXISTING LODGEPOLE PINE STAND: 20 YEARS OLD: SITE INDEX 50: OVERSTOCKED

3

BEGINNING INTEREST RATE	ENDING INTEREST RATE	INTEREST RATE INCREMENT	NUMBER OF ALTERNATIVES	INITIAL COST OR RETURNS		DISCOUNT COST OR RETURNS
00.000	00.350	00.01000	01	0	(0 = YES, 1 = NO)	0

NAMES OF ALTERNATIVES (1-20)

4

PCT = $100	ALTERNATIVES 1-5
	ALTERNATIVES 6-10
	ALTERNATIVES 11-15
	ALTERNATIVES 16-20

5

PROBLEM NUMBER	TYPE OF CALCULATION		INVESTMENT CRITERION		LENGTH OF PERIOD, YRS.	MAX. NO. YRS. IN SERIES
0001	2	1 = Perpetual, 2 = Terminable	3	1 = IROR, 2 = BC & PNW, 3 = All three	01	080

NUMBER OF YEARS IN INVESTMENT SERIES FOR EACH ALTERNATIVE (1-20)

6 080

FOR EACH ALTERNATIVE-LIST ALL ANNUAL COSTS FIRST: THEN ALL ANNUAL RETURNS.

TO INDICATE LAST COST OR RETURN-ENTER A "1" IN COLUMN 45.

"IVST" INVESTMENT ANALYSIS INPUT FORM

DO NOT KEYPUNCH

Cost or Return For Each Year (cols 9–15)	Begin In Year (cols 23–25)	End In Year (cols 33–35)	Last Entry (col 45)	
7 +100.00	001	001	0	COST TO PCT ONE ACRE - LINE# 1
+ 1.31	001	029	0	SELL OLD GROWTH TIMBR - LINE# 2
+ 50.00	030	030	0	COST TO THIN (AGE 50) - LINE# 3
+ 1.31	031	059	0	SELL OLD GROWTH - LINE# 4
+ 55.00	060	060	0	COST TO THIN (AGE 80) - LINE# 5
+ 1.31	061	080	0	SELL OLD GROWTH TIMBR - LINE# 6
- 23.69	030	030	0	HARVEST COST FOREGONE - LINE# 7
- 48.69	060	060	1	HARVEST COST FOREGONE - LINE# 8
+ 26.20	001	029	0	OLD GROWTH INCOME - LINE# 9
+125.00	030	030	0	THINNING INCOME @50 - LINE# 10
-473.80	030	030	0	INCOME FOREGONE @50 - LINE# 11
+ 26.20	031	059	0	OLD GROWTH INCOME - LINE# 12
+750.00	060	060	0	THINNING INCOME @80 - LINE# 13
-973.80	060	060	0	INCOME FOREGONE @80 - LINE# 14
+ 26.20	061	080	1	OLD GROWTH INCOME - LINE# 15
.				
.				
.				
.				
8 998 = DO ANOTHER PROBLEM				
999 = END OF PROBLEM				PUNCH

VIII. IVST: SAMPLE PROBLEM NO. 1

Precommercial Thinning
At 20 Years of Age
Followed By
Commercial Thinning
At 50 and 80 Years of Age

A. Input Values Used

Refer to Chapters V through VII for the input values used in this sample problem.

1. A specific value of $200 per MBF is assigned to mature timber in Problem #1.

2. Other costs and values are described in the previous chapter.

B. Complete IVST Worksheets

Complete and check the worksheets as shown in Chapter VII for Problem #1 (p. 38 and 39).

Keypunch and store the data in your ADP Users File. The data for Problem #1 is shown as being stored in catalog/string/file A134/Data/Data 8.

Always inspect the data file to make sure that the input information is stored correctly. Use the CONVERT system to convert the data from BCD (machine language) to ASC II (conversational language).

C. Display Stored Data

Figure 1, Problem #1, shows the exact data that has been stored in A134's users file.

The Division of Data Processing has instituted a chargeback system to record user use and cost data.

The response to user identification now requires an office and funding code in addition to the mailing code. State Office or District codes are used by the Mail Room to send ADP printouts, directed to the main-line printer, to the originating office.

Contact the State Office ADP Coordinator for assistance if any difficulties are encountered with the updated chargeback system.

```
*CONVER/DATA/DATA8
*LIST

PCT AND COMMERCIAL THIN AT 20, 50, AND 80 YEARS OF AGE
EXISTING LODGEPOLE PINE STAND; 20 YEARS OLD: SITE INDEX 50; OVERSTOCKED
    00.000    00.350  00.01000        01         0         0
PCT=$100
      0001         2         3        01       080
080

        +100.00       001       001       0
        +  1.31       001       029       0
        + 50.00       030       030       0
        +  1.31       031       059       0
        + 55.00       060       060       0
        +  1.31       061       080       0
        - 23.69       030       030       0
        - 48.69       060       060       1
        + 26.20       001       029       0
        +125.00       030       030       0
        -473.80       030       030       0
        + 26.20       031       059       0
        +750.00       060       060       0
        -973.80       060       060       0
        + 26.20       061       080       1

999

*RESAVE/DATA/DATA8
*CONVER*+A134/DATA/DATA8:BCD,C(1-80)
```

Notes: The CONVERT system is used to convert BCD (machine language) to ASCII (conversational language) for inspection of the stored data.

The resave and convert back to BCD steps are needed only if changes are made in the data or input format.

Figure 1. Listing of IVST Input Data for Problem #1.

Check the data stored in this computer file against the worksheet input form (p. 38 and 39). Use the TEXT EDITOR system to correct the file data if necessary.

D. Execute the IVST Program (L270)

1. Log on to the computer:

```
BLM COMPUTER CENTER 03/19/81 at 14.788  CHANNEL 7041 TSI

USER ID -A134
PASSWORD--
20 BLOCKS FILE SPACE AVAILABLE
```

2. Call in the IVST Program:

```
*A134/RUNL270
ENTER USER IDENTIFICATION.1/
ENTER CATALOG STRING OF DATA FILE.2/

$:PRMFL:05,R,S,A134/DATA/DATA83/

-RUN
 SNUMB # 6970T

$:PRMFL:05,R,S,A134/DATA/DATA8

-COUT

$:PRMFL:05,R,S,A134/DATA/DATA8
```

3. Monitor the progress of the program:

```
-JMON 6970T
6970T -01   WAIT CORE    ...
6970T -01   EXECUTING    ....
6970T OUTPUT WAITING     ID=YJ
*JMON WON'T MONITOR JOB IN SYOT OR SSFILE*

$:PRMFL:05,A134/DATA/DATA8
```

4. Print the program results:

```
*JOUT 6970T
FUNCTION? EPRINT 06

(EPrint - directs the printing to your remote terminal)

(DIRE ONL - directs the printing program results to the
            mainline printer in Denver)
```

---

[1]Use your mail code and name for User ID, or your State, District and new charge code as appropriate.

[2]Use the name of the data file containing worksheet inputs.

[3]Data for sample problem #1 was stored in File:A134/DATA/DATA8.

E. Reading the Printout

Selected pages of the ADP printout of sample Problem #1 have been reproduced on the following pages (Figs. 2 through 5 inc.).

Figure 2 (p. 44) shows the input data. Costs and incomes are summarized for the period (year) identified. Note that on the input form, page 39, that the $100.00 PCT cost is shown occurring in year 001, that this cost is coded "yes" in the "Initial" column and that costs and returns are discounted. Figure 2 shows the period as zero, indicating that no time has elapsed in the discounting process. Costs and returns occurring at the beginning of year #80 are shown as being discounted for 79 full years on Figure 2, page 44.

Figure 3 (p. 45) shows the PNW of all costs and all benefits independently for rates of interest from 0 to 35. The PNW at a zero interest rate is the mathematical sum of individual costs and returns.

Figure 4 (p. 46) contains B/C ratios and net PNW at rates of interest from 0 to 35 percent inclusive.

Figure 5 (p. 47) shows the IRR when the B/C Ratio equals 1.00. At this point, the PNW of all benefits and all costs equals zero.

$$\begin{pmatrix}\text{PNW of}\\ \text{Income}\end{pmatrix} - \begin{pmatrix}\text{PNW of}\\ \text{Costs}\end{pmatrix} = 0 \text{ @ } 33.5 \text{ percent}$$

Figure 2. ADP printout of input data.

PCT=$100

PERIOD	ANNUAL COST	ANNUAL RETURN
0	101.31	26.20
1	1.31	26.20
2	1.31	26.20
3	1.31	26.20
4	1.31	26.20
5	1.31	26.20
6	1.31	26.20
7	1.31	26.20
8	1.31	26.20
9	1.31	26.20
10	1.31	26.20
11	1.31	26.20
12	1.31	26.20
13	1.31	26.20
14	1.31	26.20
15	1.31	26.20
16	1.31	26.20
17	1.31	26.20
18	1.31	26.20
19	1.31	26.20
20	1.31	26.20
21	1.31	26.20
22	1.31	26.20
23	1.31	26.20
24	1.31	26.20
25	1.31	26.20
26	1.31	26.20
27	1.31	26.20
28	1.31	26.20
29	26.31	-348.80
30	1.31	26.20
31	1.31	26.20
32	1.31	26.20
33	1.31	26.20
34	1.31	26.20
35	1.31	26.20
36	1.31	26.20
37	1.31	26.20
38	1.31	26.20
39	1.31	26.20
40	1.31	26.20
41	1.31	26.20
42	1.31	26.20
43	1.31	26.20
44	1.31	26.20

PCT=$100

PERIOD	ANNUAL COST	ANNUAL RETURN
45	1.31	26.20
46	1.31	26.20
47	1.31	26.20
48	1.31	26.20
49	1.31	26.20
50	1.31	26.20
51	1.31	26.20
52	1.31	26.20
53	1.31	26.20
54	1.31	26.20
55	1.31	26.20
56	1.31	26.20
57	1.31	26.20
58	1.31	26.20
59	6.31	-223.80
60	1.31	26.20
61	1.31	26.20
62	1.31	26.20
63	1.31	26.20
64	1.31	26.20
65	1.31	26.20
66	1.31	26.20
67	1.31	26.20
68	1.31	26.20
69	1.31	26.20
70	1.31	26.20
71	1.31	26.20
72	1.31	26.20
73	1.31	26.20
74	1.31	26.20
75	1.31	26.20
76	1.31	26.20
77	1.31	26.20
78	1.31	26.20
79	1.31	26.20

Figure 3. Present net worth of costs and present net worth of benefits.

ALTERNATIVE * PCT=$100

RATE	BENEFITS	COSTS
0.	1471.00	234.80
1.00	1032.46	194.14
2.00	773.25	168.74
3.00	612.16	152.23
4.00	506.69	141.09
5.00	433.94	133.31
6.00	381.25	127.70
7.00	341.37	123.54
8.00	310.04	120.38
9.00	284.63	117.93
10.00	263.52	116.00
11.00	245.61	114.44
12.00	230.17	113.17
13.00	216.71	112.11
14.00	204.84	111.23
15.00	194.29	110.48
16.00	184.84	109.84
17.00	176.34	109.28
18.00	168.65	108.79
19.00	161.67	108.37
20.00	155.30	107.99
21.00	149.47	107.65
22.00	144.12	107.34
23.00	139.19	107.07
24.00	134.63	106.82
25.00	130.42	106.59
26.00	126.51	106.38
27.00	122.87	106.19
28.00	119.48	106.01
29.00	116.31	105.84
30.00	113.35	105.69
31.00	110.57	105.55
32.00	107.96	105.41
33.00	105.50	105.29
34.00	103.18	105.17
35.00	100.99	105.06

Figure 4. Present net worth and benefit cost ratio.

PCT=$100

RATE	*PNW	B/C*
0.	1236.20	6.26
1.00	838.32	5.32
2.00	604.51	4.58
3.00	459.93	4.02
4.00	365.59	3.59
5.00	300.63	3.26
6.00	253.55	2.99
7.00	217.83	2.76
8.00	189.65	2.58
9.00	166.70	2.41
10.00	147.52	2.27
11.00	131.17	2.15
12.00	117.01	2.03
13.00	104.60	1.93
14.00	93.61	1.84
15.00	83.81	1.76
16.00	75.01	1.68
17.00	67.06	1.61
18.00	59.86	1.55
19.00	53.30	1.49
20.00	47.31	1.44
21.00	41.82	1.39
22.00	36.77	1.34
23.00	32.12	1.30
24.00	27.82	1.26
25.00	23.83	1.22
26.00	20.13	1.19
27.00	16.68	1.16
28.00	13.47	1.13
29.00	10.47	1.10
30.00	7.66	1.07
31.00	5.02	1.05
32.00	2.54	1.02
33.00	0.21	1.00
34.00	-1.99	0.98
35.00	-4.06	0.96

Figure 5. Internal rate of return.

PCT=$100

* RATE	PNW *
0.	1236.20
1.00	838.32
2.00	604.51
3.00	459.93
4.00	365.59
5.00	300.63
6.00	253.55
7.00	217.83
8.00	189.65
9.00	166.70
10.00	147.52
11.00	131.17
12.00	117.01
13.00	104.60
14.00	93.61
15.00	83.81
16.00	75.01
17.00	67.06
18.00	59.86
19.00	53.30
20.00	47.31
21.00	41.82
22.00	36.77
23.00	32.12
24.00	27.82
25.00	23.83
26.00	20.13
27.00	16.68
28.00	13.47
29.00	10.47
30.00	7.66
31.00	5.02
32.00	2.54
33.00	0.21
33.50	1.00

*Rate of return (IRR) on investments in sample problem #1 is 33.5 percent.

IX. IVST: SAMPLE PROBLEM NO. 2

Precommercial Thinning
At 20 Years of Age
Followed By
Commercial Thinning
At 50 and 80 Years of Age

A. Input Values Used

Refer to Chapters V through VIII for the input values used in sample Problem #1.

A value of $100 per MBF is assigned to mature timber stumpage in this problem (Problem #2). Other values and costs are not changed.

The object of this comparison study is to determine the effect upon IRR, PNW and B/C ratio when the stumpage value is varied from $100 to $200 per MBF and all other costs and incomes remain constant.

B. Worksheet Computational Data

1. Costs: All costs for Problem #2 are identical to costs of Problem #1.

2. Incomes

   a. Mature timber: An annual income of $13.10 is received for mature timber instead of $26.20 as used in Problem #1. See lines 9, 12, and 15 of Item #7 of the input worksheet form.

      131 bd ft @ $100.00 MBF = $13.10

   b. Thinning at 50 years of age: A loss of $236.90 is incurred during year #30 when thinnings are sold because less high value old growth is sold. See line 12 of Item #7 of the input worksheet form.

      (2500 - 131 bd ft) @ $100.00 per MBF = $236.90

   c. Thinning at 80 years of age: A loss of $486.90 is incurred during year #60 when thinnings are sold in place of old growth. See line 14 of Item #7 of the input worksheet form.

      (5000 - 131 bd ft) @ $100.00 per MBF - $486.90

   d. Thinning incomes: The income from thinnings at 50 and 80 years remains the same as in Problem #1.

C. Keypunch and Edit Data: Record the data updates for problem #2 in your User's UMC file through the use of the CONVERT and TEXT EDIT Systems.

D. List the Edited Data - Problem #2: Figure 6 shows the edited data.

```
*CONVER /DATA/DATA8
*LIST

PCT AND COMMERCIAL THIN AT 20, 50, AND 80 YEARS OF AGE
EXISTING LODGEPOLE PINE STAND; 20 YEARS OLD; SITE INDEX 50; OVERSTOCKED
    00.000    00.350  00.01000        01         0
PCT-$100
      0001         2         3        01       020
080
         +100.00      001       001         0
         +  1.31      001       029         0
         + 50.00      030       030         0
         +  1.31      031       059         0
         + 55.00      060       060         0
         +  1.31      061       080         0
         - 23.69      030       030         0
         - 48.69      060       060         1
         + 13.10#     001       027         0
         +125.00      030       030         0
         -236.90#     030       030         0
         + 13.10#     031       059         0
         +750.00      060       060         0
         -486.90#     060       060         0
         + 13.20#     061       080         1

999

#These input values were changed through the use of the EDIT system for
Problem No. 2.  All other inputs remain the same as shown in Problem No. 1.
```

Figure 6. Listing of IVST Input Data for Problem #2.

Refer to worksheets #1 and #2 (p. 38 and 39) for an explanation of unchanged data.

E. Execute the IVST Program

1. Log onto computer and call in the IVST program:

```
(* A134/RUNL270)

ENTER USER IDENTIFICATION,A134.F. HORAK D-450
ENTER CATALOG STRING OF DATA FILE.A134/DATA/DATA8

$:PRMFL:05,R,S,A134/DATA/DATA8

-RUN
 SNUMB #7424T

$:PRMFL:05,R,S,A134/DATA/DATA8

-COUT

$:PRMFL:05,R,S,A134/DATA/DATA8
```

2. Monitor the progress execution:

```
*JMON 7424T
7424T -01   EXECUTING
7424T OUTPUT WAITING     ID=AP
*JMON WON'T MONITOR JOB IN SYOT OR SSFILE*

$:PRMFL:05,R,S,A134/DATA/DATA8
```

3. Direct the printing subroutine:

```
*JOUT 7424T
FUNCTION?DIRE ONL

$:PRMFL:05,R,S,A134/DATA/DATA8
```

Log off from the Time Sharing System:

```
BYE

   1 TEMPORARY FILES CREATED.

NULL
**COST:  *   0.97 TO DATE:  $2294.74=  1%
**ON AT 13.036 - OFF AT 13.168
```

Note: This analysis costs less than $1.00 to run on the computer.

F. Problem No. 2 Results

The following figures (Figures 7 through 10) are copies of portions of the IVST printout from Problem #2.

Figure 7 shows how the computer summarized the separate cost and returns designated on the input form and reassigned values for each year of the terminable service. See page 52.

Figure 8 shows the total discounted costs and benefits computed for each interest level as directed by the input form. See page 53.

Figure 9 shows the PNW and the B/C ratio computed for each rate of interest. See page 54.

Figure 10 shows the IRR computed. The IRR is the interest rate earned at B/C ratio of 1-1 or when the PNW is zero. See page 55.

Figure 7. ADP printout of input data.

PCT=$100

PERIOD	ANNUAL COST	ANNUAL RETURN
0	101.31	13.10
1	1.31	13.10
2	1.31	13.10
3	1.31	13.10
4	1.31	13.10
5	1.31	13.10
6	1.31	13.10
7	1.31	13.10
8	1.31	13.10
9	1.31	13.10
10	1.31	13.10
11	1.31	13.10
12	1.31	13.10
13	1.31	13.10
14	1.31	13.10
15	1.31	13.10
16	1.31	13.10
17	1.31	13.10
18	1.31	13.10
19	1.31	13.10
20	1.31	13.10
21	1.31	13.10
22	1.31	13.10
23	1.31	13.10
24	1.31	13.10
25	1.31	13.10
26	1.31	13.10
27	1.31	13.10
28	1.31	13.10
29	26.31	-111.90
30	1.31	13.10
31	1.31	13.10
32	1.31	13.10
33	1.31	13.10
34	1.31	13.10
35	1.31	13.10
36	1.31	13.10
37	1.31	13.10
38	1.31	13.10
39	1.31	13.10
40	1.31	13.10
41	1.31	13.10
42	1.31	13.10
43	1.31	13.10
44	1.31	13.10

PCT=$100

PERIOD	ANNUAL COST	ANNUAL RETURN
45	1.31	13.10
46	1.31	13.10
47	1.31	13.10
48	1.31	13.10
49	1.31	13.10
50	1.31	13.10
51	1.31	13.10
52	1.31	13.10
53	1.31	13.10
54	1.31	13.10
55	1.31	13.10
56	1.31	13.10
57	1.31	13.10
58	1.31	13.10
59	6.31	263.10
60	1.31	13.20
61	1.31	13.20
62	1.31	13.20
63	1.31	13.20
64	1.31	13.20
65	1.31	13.20
66	1.31	13.20
67	1.31	13.20
68	1.31	13.20
69	1.31	13.20
70	1.31	13.20
71	1.31	13.20
72	1.31	13.20
73	1.31	13.20
74	1.31	13.20
75	1.31	13.20
76	1.31	13.20
77	1.31	13.20
78	1.31	13.20
79	1.31	13.20

Figure 8. Present net worth of benefits and present net worth of costs.

ALTERNATIVE * PCT=$100

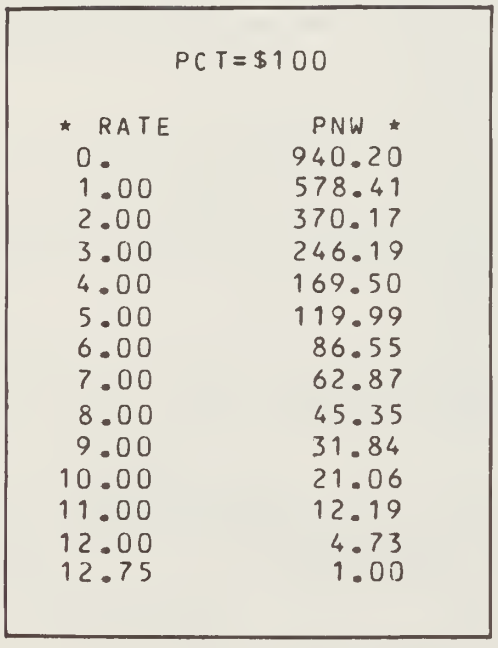
RATE	BENEFITS	COSTS
0.	1175.00	234.80
1.00	772.55	194.14
2.00	538.91	168.74
3.00	398.42	152.23
4.00	310.59	141.09
5.00	253.30	133.31
6.00	214.25	127.70
7.00	186.42	123.54
8.00	165.74	120.38
9.00	149.78	117.93
10.00	137.06	116.00
11.00	126.63	114.44
12.00	117.89	113.17
13.00	110.44	112.11
14.00	103.98	111.23
15.00	98.33	110.48
16.00	93.32	109.84
17.00	88.87	109.28
18.00	84.86	108.79
19.00	81.25	108.37
20.00	77.97	107.99
21.00	74.99	107.65
22.00	72.26	107.34
23.00	69.75	107.07
24.00	67.44	106.82
25.00	65.31	106.59
26.00	63.33	106.38
27.00	61.50	106.19
28.00	59.79	106.01
29.00	58.19	105.84
30.00	56.70	105.69
31.00	55.31	105.55
32.00	54.00	105.41
33.00	52.76	105.29
34.00	51.60	105.17
35.00	50.51	105.06

Figure 9. Present net worth and benefit/cost ratio.

PCT=$100

RATE	*PNW	B/C*
0.	940.20	5.00
1.00	578.41	3.98
2.00	370.17	3.19
3.00	246.19	2.62
4.00	169.50	2.20
5.00	119.99	1.90
6.00	86.55	1.68
7.00	62.87	1.51
8.00	45.35	1.38
9.00	31.84	1.27
10.00	21.06	1.18
11.00	12.19	1.11
12.00	4.73	1.04
13.00	-1.68	0.99
14.00	-7.25	0.93
15.00	-12.15	0.89
16.00	-16.51	0.85
17.00	-20.41	0.81
18.00	-23.93	0.78
19.00	-27.12	0.75
20.00	-30.01	0.72
21.00	-32.66	0.70
22.00	-35.09	0.67
23.00	-37.32	0.65
24.00	-39.38	0.63
25.00	-41.28	0.61
26.00	-43.05	0.60
27.00	-44.69	0.58
28.00	-46.22	0.56
29.00	-47.65	0.55
30.00	-48.98	0.54
31.00	-50.24	0.52
32.00	-51.41	0.51
33.00	-52.52	0.50
34.00	-53.56	0.49
35.00	-54.55	0.48

Figure 10. Internal rate of return.



PCT=$100

* RATE	PNW *
0.	940.20
1.00	578.41
2.00	370.17
3.00	246.19
4.00	169.50
5.00	119.99
6.00	86.55
7.00	62.87
8.00	45.35
9.00	31.84
10.00	21.06
11.00	12.19
12.00	4.73
12.75	1.00

*Rate of return (IRR) of investments shown in sample problem #2 is 12.75. Benefit/cost ratio = 1:1.

X. SENSITIVITY ANALYSIS

Plot the B/C ratio in relation to percent of interest on the returns from problems #1 and #2 as shown on Figure 11, page 57. Note that the IRR is 12.75 percent for a stumpage value of $100 per MBF and 33.5 percent for a stumpage value of $200.

Did you catch the error in Problem #2 where an annual return of $13.20 for year 60 through year 79 was used instead of the correct figure of $13.10? This error causes an insignificant effect upon the analysis.

Figure 11 shows that both trial runs ($100 and $200 stumpage) produce a positive rate of return (12.75% and 33.5% respectively). At this point, we do not know how low the stumpage price of mature timber must be to provide a positive B/C ratio for any rate of interest below 12.75%.

It is suggested that the "halving" procedure be used in making sensitivity tests of the various input items. For example, old growth stumpage values of $400, $200, $100, $50, $25, and $12.50 may be used to develop results that can be easily graphed for an analysis of the effects of stumpage when all other cost or income items remain constant.

If the results of additional problems are plotted on the graph (Fig. 11), the minimum stumpage value can be interpolated which will satisfy the approved investment rate.

Since compound interest involves logarithmic functions (not straight line projections), interpolations and extrapolations must be proportioned on the graphic display accordingly.

It is suggested that District analysts prepare a set or series of graphic displays of typical local sets of cost and income data. These canned or preliminary studies would then be available for a quick reference visual inspection to approximate break-even points for screening project proposals, solicitation of bids, or in-house cost accounting.

State Office ADP Coordinators keep abreast of changes and updates of the Time Sharing Systems in operation.

If any difficulty is encountered with the operation of the IVST program or with developing inputs for the program, contact the Division of Resource Systems, D-470, Denver Service Center, or Division of Computer Applications, D-220, USDI, BLM, Bldg. 50, Denver Federal Center, Denver, Colorado 80225.

SENSITIVITY ANALYSIS

PRECOMMERCIAL THINNING followed by TWO COMMERCIAL THINNINGS

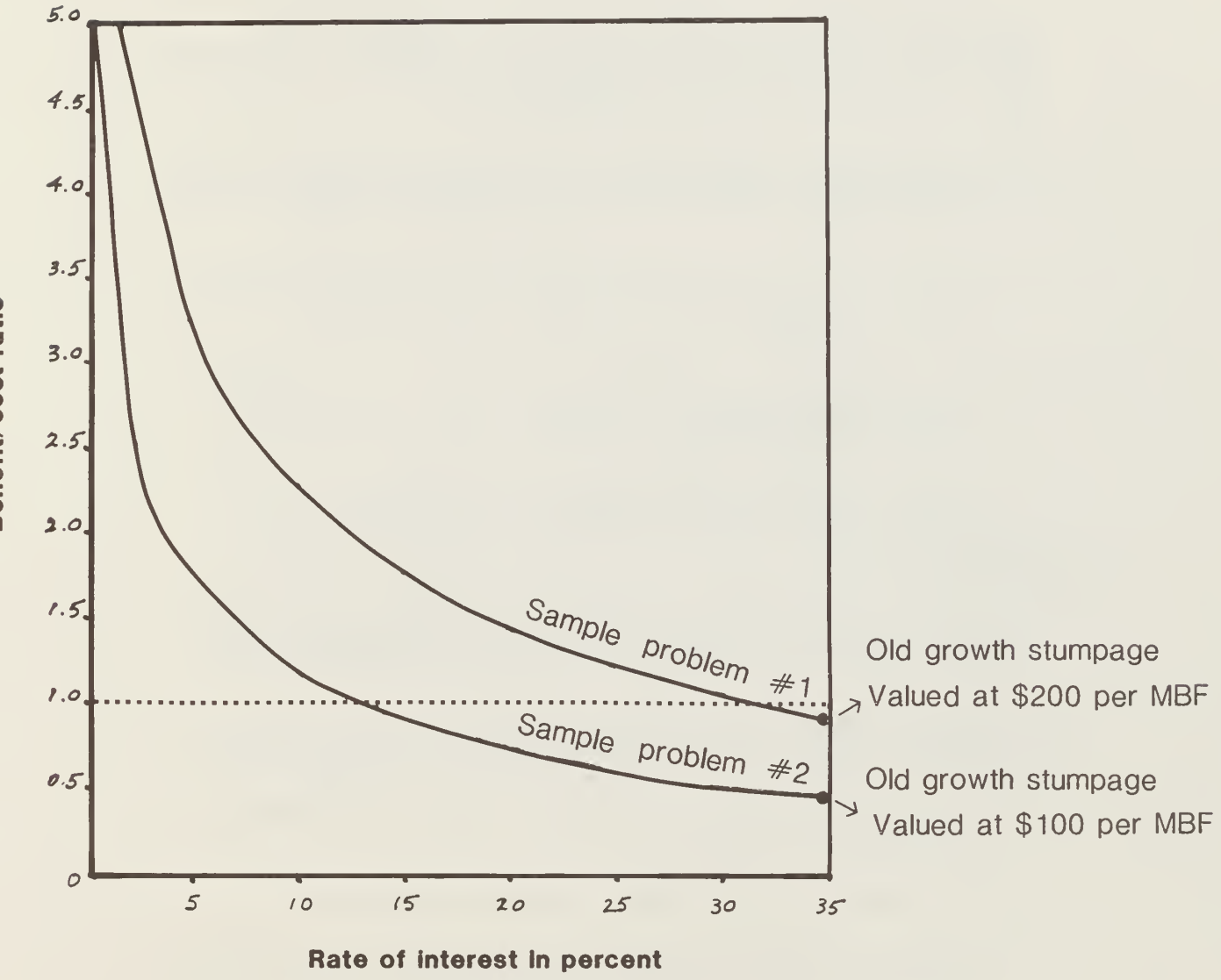


Figure 11. Benefit/cost ratios at various interest rates.

APPENDIX 1 - Project Benefit/Cost Supplements

A. Reforestation

1. Direct Costs

Artificial reforestation costs are not included in the examples contained in this publication. However, if an annual reforestation cost is involved in replanting harvested acreage, the following procedure may be used.

a. Determine an average reforestation cost per acre from all reforestation costs and all mature harvest acreage planned for the year.

b. Compute the extra acreage harvested annually due to the ACE of thinning one acre. Carry out acreages to four decimal places.

c. Multiply annual reforestation cost per acre by the ACE acreage developed in "b" above.

d. Input this annual cost onto the IVST form for all years except those in which thinnings are harvested.

2. Foregone Costs

For those years when thinning volume is harvested, the reforestation costs are foregone on all of the equivalent mature acreage that is not harvested.

In sample problems #1 and #2, the acreage of mature timber not harvested is computed as follows:

a. Average volume per acre of mature timber is 12,000 bd ft (see Chapter V, part B).

b. The annual cut is 10 MMBF. (Chapter V, part C).

c. Without a thinning regime, the area harvested annually is 833.3333 acres. The ACE adds 0.01095 extra cutting acres.

d. With a thinning regime of one acre, the annual cut is 10 MMBF plus 131.5 BF. The area harvested annually is 833.3333 plus 0.01095 acres = 833.34428 acres.

e. During year #30, when 2,500 bd ft of thinnings are harvested, the following equivalent acreage of old growth is not cut:

$$\frac{2,500 - 131.5}{12,000} = 0.19737 \text{ acres}$$

The mature area harvested during year #30 is:

$$833.34428 - \frac{2,500}{12,000} (-0.20833) = 833.13596 \text{ acres}$$

f. Multiply the average reforestation cost per acre times the acreage developed in (e) and insert this dollar value in the IVST program as a negative cost, i.e., a cost foregone during this one year.

g. Follow the same procedure as in "f" for year #60 when the second thinning operation is planned.

Since all reforestation functions are cost items, the positive reforestation costs are input as "plus" cost items and the reforestation costs saved are "negative" cost items.

It may be advisable to compile to the extent possible--reforestation costs, success rates, acreage treated and acreage needing treatment--records for the past five to ten years and the total acreage harvested within the SYU for the same period of time. During any one year all, none, or some intermediate percentage of the acres harvested may require artificial reforestation treatment.

Other annual or periodic incomes or costs may be treated in the same manner as reforestation costs. The principal point to remember is to choose typical, average data on a forest-wide basis.

B. Supplements

(Additional benefit/cost ratio supplements may be placed here.)

APPENDIX 2 - Listing: JCL and CRUN Language

This data is shown for informational purposes only.

1. JOB CONTROL LANGUAGE

```
*OLD A185/JCL/EXL270,R
*LIST

##N,J
$:IDENT:IIIII
$:OPTION:FORTRAN
$:SELECT:A134/OBJ/L270OBJ
$:EXECUTE
$:LIMITS:,35K
$:PRMFL:05,R,S,DDDDD
$:ENDJOB
```

2. CRUN LISTING

```
*LIST /RUNL270

##*NULL
OLD A185/JCL/EXL270,R
SYST
EDIT CASE
$*$MARK
$*$MARK
RS:/IIIII/
$*$USER=#ENTER USER IDENTIFICATION.
$*$NULL
RS:/DDDDD/
$*$USER=#ENTER CATALOG STRING OF DATA FILE.
$*$NULL
COUT NULL
RUN
COUT
```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